

# 1 Fundamentals of production

## 1.1 What is production

Production is the process of converting raw materials into products. It comprises (1) the design of the product, (2) the selection of raw materials and (3) the sequence of processes through which the product will be produced. The word product means something that is produced.

Production is generally a complex activity involving a wide variety of resources and activities, such as the following:

- Product design
- Purchasing
- Marketing
- Machinery and tooling
- Manufacturing
- Sales
- Process planning
- Production control
- Shipping
- Materials
- Support services
- Customer service

The Production activities must be responsive to several demands and trends:

- 1- A product must fully meet design requirements and product specifications and standards.
- 2- A product must be manufactured by the most environmentally friendly and economical methods.
- 3- Quality must be at each production stage, rather than tested in after the product is made.
- 4- The level of quality should be appropriate to the product's use.
- 5- Production methods must be flexible to changes in market demands, new materials, types of products, production rates and quantities, and on-time delivery requirements.

## 1.2 Basic Methods of Production

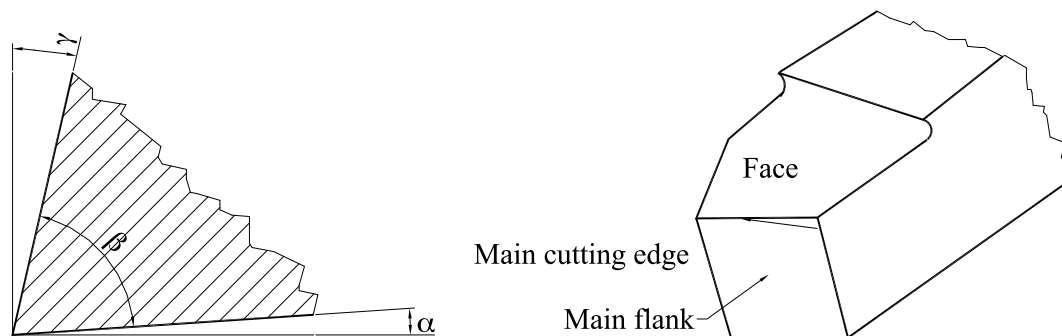
The methods of production are classified into two main groups:

1. **Non-cutting shaping:** It is the processing of raw materials without chip formation (failure of cohesion of grains). Examples of these methods are: casting, forging, rolling, welding, ... etc. Those processes are used mainly for production of semi-products which are usually not accurate in shape, size and have bad surface quality.
2. **Machining:** It is the gradual metal removal from the surface of the product due to failure of cohesion of material grains in the form of chips. Examples of these methods are: turning, milling, drilling, grinding, ... etc. These processes are used mainly for production of final product which is usually accurate in shape, size and dimension and can be controlled to the required surface quality.

### 1.3 Basic Concepts of Machining

A machining system comprises the following basic elements:

1. **Workpiece (w.p.):** From the designer working drawing, the following data is known:
  - Shape, dimensions, accuracy and surface quality.
  - Workpiece material and its properties.
2. **Tool:** A cutting tool to remove the excess material of the workpiece in the form of chip.
  - The cutting action is performed by the tool wedge which is formed by the tool face and flank which are intersected on the main cutting edge (m.c.e.).
  - The tool should be made of special material and should be shaped by grinding to have a certain geometry which enable the tool to cut (the shown figure demonstrates the geometry of the tool used for turning operation).



- The tools are classified according to the number of cutting edges into:
  - ❑ Single point tool (turning, shaping and slotting tools).
  - ❑ Double point tool (twist drill).
  - ❑ Multi-point tool (milling cutters, reamers).
  - ❑ Many points tool (grinding, honing, ...).
- 3. **Machine tool (M/c):** The machine tool provides the necessary power and motions to the tool and/or the workpiece to enable the tool wedge to penetrate into the workpiece material.

### 1.4 Machine tool motions

The cutting motions of the machine tool can be described by two motions:

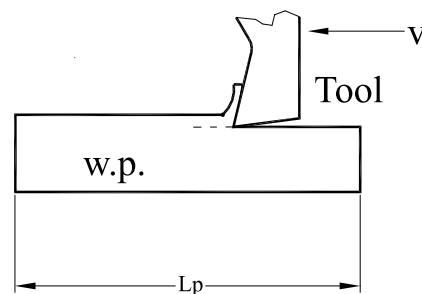
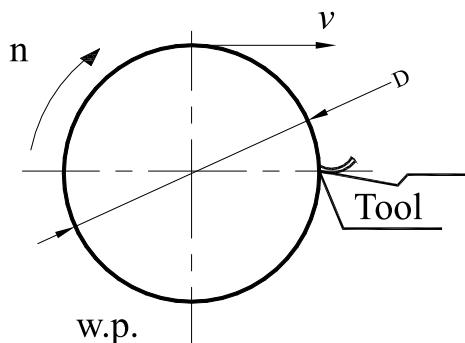
- i. **Main Motion (M.M.):** which is usually the basic motion of the machine tool and creates the generating line of the surface to be machined and also it consumes most of the M/c power. The main motion (M.M.) can be classified into:
  - Rotary (Turning, Milling, Drilling, ...).
  - Rectilinear (Shaping, slotting, ...)
  - Combined (honing)

- The main motion is either performed by the tool (drilling, milling) or by the w.p. (Turning and Planning).
- The M.M. is represented by cutting speed ( $v$ ) which is usually given in (m/min) or in (m/sec) in the case of Grinding.
- The cutting speed ( $v$ ) depends on: tool material, w.p. material, tool geometry, type of process, quality of surface finish, cooling and type of machine tool.

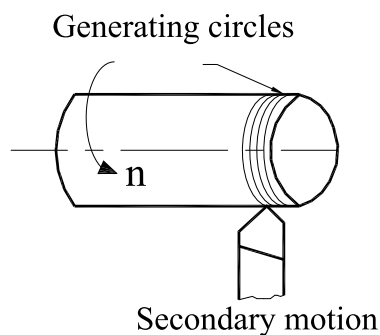
$$v = \frac{\pi D n}{1000}$$

$D$  is the Workpiece diameter and  $n$  is the number of revolution of the Workpiece.

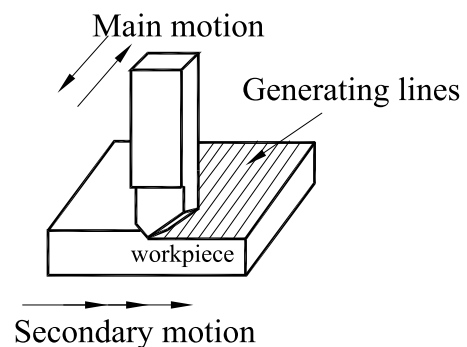
- Also the cutting motion can be continuous as in turning and drilling or interrupted as in milling, shaping, etc.



- ii. **Secondary Motion (S.M.):** It is the motion of the tool or w.p. to sweep the generating line formed by the main motion along the surface to be machined.

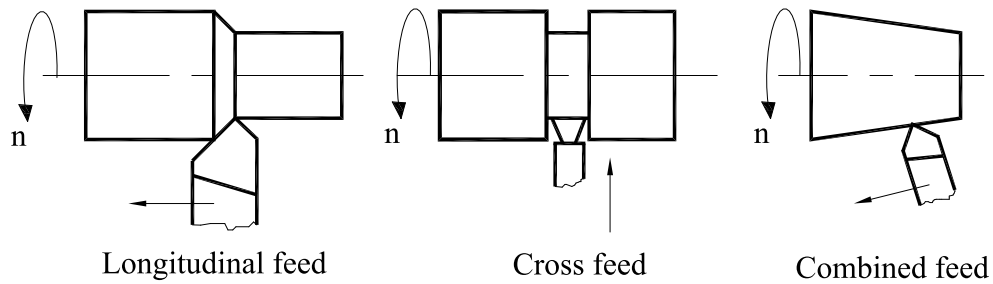


**Turning process**



**Shaping process**

- The secondary motion (S.M.) consumes a small portion of power of machine motor. It can be either continuous (as in turning, drilling) or interrupted (slotting and shaping).
- The S.M. is performed either by tool (turning, drilling) or by the w.p. (milling, shaping) or by both as in gear hopping. Some types of S.M. in turning process are shown below:



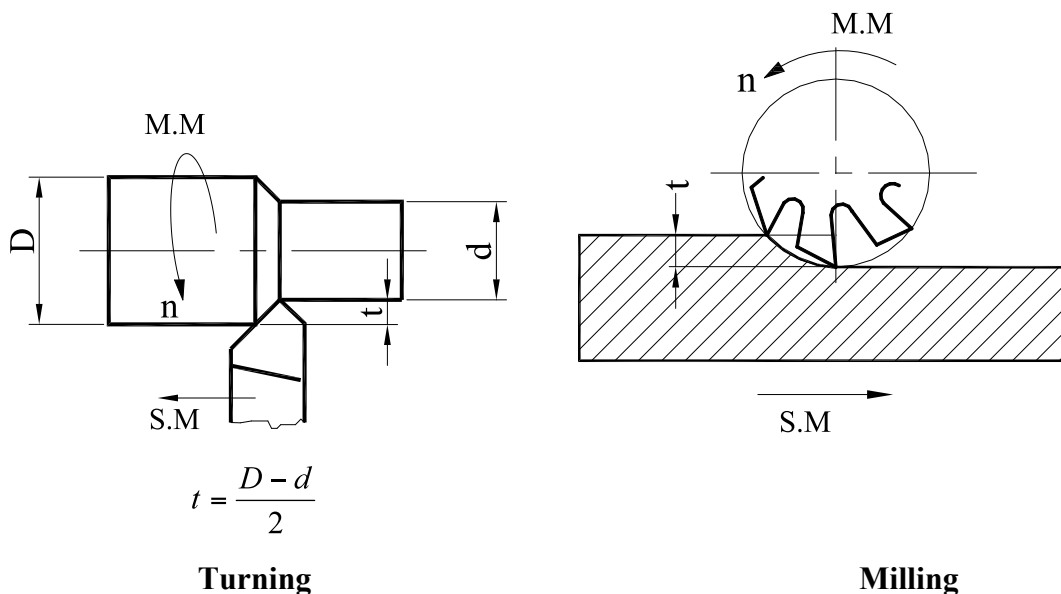
➤ The feed represents the S.M. and is denoted by  $s$  and is usually given as:

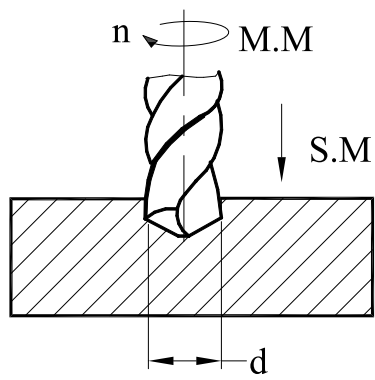
- mm/rev ( $s$ ) (turning)
- mm/double stroke ( $s_d$ ) (Shaping)
- mm/tooth ( $s_z$ ) milling
- mm/min ( $s_m$ ) (milling)

where:  $s_m = s_z z n$                       ( $z \dots$  no. of cutting teeth and  $n \dots$  no of revolutions).

The selection of the **feed rate** depends on:

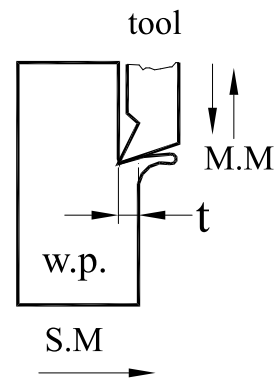
- Type of operation (**roughing or finishing**)
  - **Workpiece material and tool material**
  - **Rigidity of system** (M/c – tool – w.p.).
  - Required accuracy
  - **Machine tool construction**
  - Speed and **depth of cut.**
- Beside  $v$  and  $s$ , the depth of cut ( $t$ ) represents the depth of w.p. material which will be removed. The value of ( $t$ ) is higher in roughing and lower in finishing processes.
- The parameters  $v$ ,  $s$  and  $t$  are called cutting conditions.
- The following figures show the cutting motions in some machining processes.



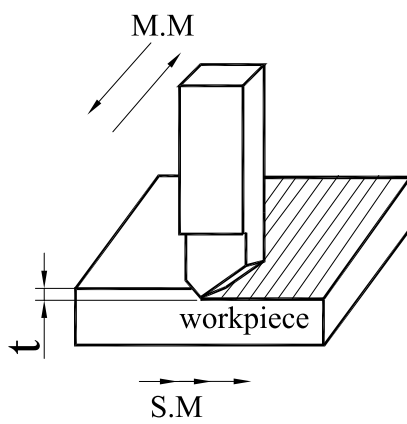


$$t = \frac{D}{2}$$

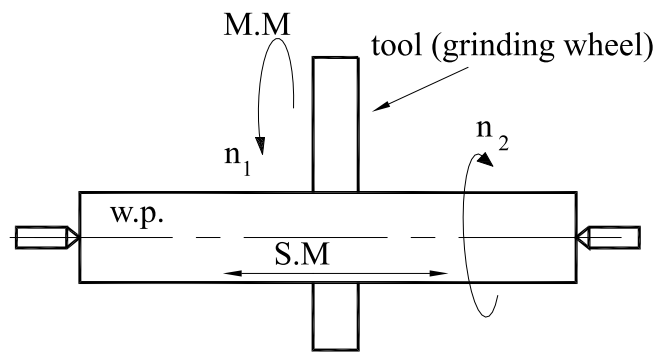
**Drilling**



**Slotting**



**Shaping**



**Grinding**